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The Mathematics of the Sky



By

CHAS. J. BURTON



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The Mathematics of the Sky

OR

***The Stupendous Grasp of
Figures as Applied to the
Heavenly Bodies***

By

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Ph. D., D. D. LL. D.

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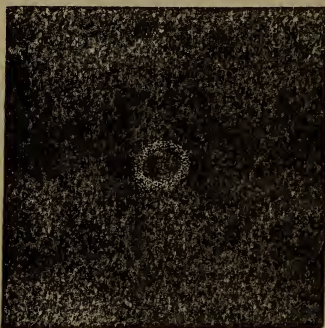
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By C. J. Burton

THE RING NEBULA IN LYRA



A very few ring Nebulas are known, of which the one in Lyra is the finest. It has a very faint star of the fifteenth magnitude near its center. It was discovered by Darquier in 1779, while following Bode's comet of that year. It is located about 10 degrees southeast of the bright star Vega.

JAN -3 1921

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PREFACE

Reveling in the depths of space, reflecting on the grandeur of the universe and calculating on the vastness of its dimensions have brought many delightful hours while preparing the material for this book.

It is not a dry and prosy collection of numbers brought together for the sake of looking at them, but the study of the heavens which is back of the book fires the imagination and stirs the soul to grander conceptions of the magnificence of the universe, and to nobler aspirations and reverence for the God who made it. May every hour spent in reading this book fill the mind of the reader with more reverent thoughts concerning Him who created all things.

In locating various stars, clusters and nebulas I have generally spelled out the words **degrees** and **minutes**, because the signs for degrees and minutes of an arc are not ordinarily supplied by the linotype.

CHAS. J. BURTON.

Minneapolis, Minn., May 1, 1920.

PRELIMINARY THOUGHTS

"Science interpreted is theology."

"Deity works by methods and means."

"Science prosecuted to its conclusions leads to God."

"The elucidation of the great problems of philosophic or speculative theology is, indeed, the highest function of science."

"It is not for its facts, but for the significance of the facts, that science is valuable."

"To accumulate the data of science is good; to interpret them is the noblest prerogative of a thinking being."

"All our learning would in reality be but the 'vanity' which it is sometimes reproached with being if it could reflect no light upon the origin, the nature, the duty, and the destiny of man."—Winchell.

NATURE A REVELATION

We cannot resist the conviction that Nature is intended as a revelation of God to all intelligences. If it be so intended, Nature must be capable of fulfilling the offices of a revelation, and a knowledge of her phenomena and laws must afford the data of a theology.

Despite the skepticism of a certain school of recent writers, the phenomena of the universe continue to inspire in the soul of man emotions of religious reverence and worship. To the mass of mind, as to the intelligence of Socrates, and Plato, and Kepler, and Newton, and Galen, and Paley, and Buckland, the order of the Cosmos proclaims an infinite intelligence.—Winchell.

“Lift up your eyes on high, and behold who hath created these things, that brought out their host by number: He calleth them all by names by the greatness of His might, for that He is strong in power, not one faileth.” Isa. 40:26.

“Is not God in the height of heaven? and behold the height of the stars, how high they are! And thou sayest, how doth God know? Can He judge through the dark cloud? thick clouds are a covering to him, that he seeth not; and He walketh in the circuit of heaven.” Job 22:12-14.

DONATI'S COMET

This comet which appeared in 1858 was a subject of universal wonder. Its

tail was 50,000,000 miles in length, and its head was 250,000 miles in diameter. It passed over the first magnitude star, Arcturus, Oct. 5, 1858, and came nearest the earth on Oct. 10 of the same year. It remained visible for more than 9 months, and will not appear again for nearly 2,000 years.

THE TELESCOPE AND JUPITER'S FAMILY

Not until June 7, 1610 was it known that Jupiter had any moons. Galileo found the 4 larger ones on that memorable night with his 30-inch "Optic Tube." A new era was then opened in astronomy. These 4 moons are known by the mythological names of Io, Europa, Ganymede, and Callisto. During nearly 300 years from Galileo's triumph to the Lick Refractor these 4 moons of Jupiter were supposed to be the full number, but a fifth satellite was added by E. E. Barnard at Mt. Hamilton in Sept., 1892. It has a period of 11 hours and 57 minutes and is 112,500 miles from the planet. Two additional moons were added to Jupiter's system in Dec. 1904 and Jan. 1905 by Prof. Perrine of the Lick Observatory. Finally on Feb. 28, 1908, P. Melotte of Greenwich Observatory,

found an eighth moon of Jupiter. Its movement is retrograde, which anomaly is of vast cosmical importance.

A TELESCOPE ON THE NEAREST STAR TO US

If you could stand on Alpha Centauri, the nearest star to the solar system, ($4\frac{1}{2}$ light years away), and look at our sun, it would appear no brighter than Polaris does to us, so great is its distance, and you could not see a single one of our planets even if you should look through Lord Rosse's great 60-foot telescope, which is 6 feet in diameter.

The Mathematics of the Sky

CHAPTER ONE

THE TELESCOPE AND THE UNIVERSE

1. *The Telescope.*

While "the eye is not satisfied with seeing," (Eccl. 1:8), the telescope invented three hundred years ago has come to assist the eye, and now enables it to look out into space and bring to view millions of suns that are known to be hundreds of light years from the solar system.

This instrument has given man a broader view of the bigness and magnificence of the Universe. The human eye unaided can see distinctly not more than seven thousand stars, but if one should look through one of the great telescopes, he would be astonished to find at least a hundred millions of luminous suns in space. Sir William Herschel calculated that his twenty-foot reflector would penetrate into space and reach stars that are nine hundred times the distance of Sirius, and that his forty-foot reflector would bring to view stars that are twenty-eight hundred times the same distance. This is vast, simply enormous. Mr. Herschel's forty-foot reflector, with an object glass of 48 inches, showed stars up to the eighteenth magnitude of our present day classifications. Sirius is known to be more than fifty trillions of miles from us, which means that it is eight and a half light years from the Solar System.

While the Yerkes and Lick telescopes have magnifying powers of more than three thousand diameters, such instruments being intended to study the heavenly bodies in detail, the glasses that give the best satisfaction to the average person are of comparatively

moderate magnifying power, say about two hundred to three hundred diameters.

No minister, or other educated person, can afford to omit from his curriculum of study God's great Book of Nature. It should accompany the study of Revelation, the Holy Scriptures.

As we look out upon God's great universe and behold the beauty, the grandeur and the magnificence of His works, either with the naked eye or by the help of the telescope, we are constrained to say in the language of the Psalmist, "O Lord, how manifold are Thy works! In wisdom hast Thou made them all; the earth is full of Thy riches." Psa. 104:24.

2. *The Universe.*

From the Latin *Universum*. *Unus* one and *vertere* to turn, that is, turned into one, combined into one whole; all created things viewed as one system.

I. *What?*

1. *Stars or Suns.*

(1) Luminous ones. The telescope finds at least 100,000,000.

(a) First magnitude stars, 20 in all.

(b) Double stars, at least 12,-

000 couples have been found. Also many triples and quadruples.

(c) Variable stars.

(d) Temporary stars.

(e) The solar system, composed of the sun and 8 larger planets, 26 moons, and near 600 asteroids, also meteors and comets.

(2) Opaque. Probably millions of these also.

2. *Nebulae*. Ten thousand have been catalogued. Estimated to be at least one hundred and twenty thousand of them in the heavens. The most prominent are:

(1) The Great Nebula in Orion.

(2) Ring Nebula in Lyra.

(3) The Trifid Nebula.

(4) Dumb-bell Nebula.

(5) Great Spiral Nebula.

(6) Great Nebula in Andromeda.

3. *Star Clusters*. Most noted are,

(1) The Pleiades.

(2) The Hyades.

(3) The Praesepe.

(4) Great cluster in Hercules.

4. *Comets*. Many millions of these, some invisible to the naked eye,

some few very bright and striking.

They are divided into short period and long period comets and those that never return to the solar system after one visit.

II. *Extent?* Known only to the Creator, but it is known to be vast. Sir Wm. Herschel calculated that his 40-foot reflector reaches stars 2800 times the distance of Sirius, and this star is known to be fifty trillions of miles from the solar system, or eight and one-half light years away from us.

III. *How and When?* "In the beginning God *created* the heavens and the earth." Gen. 1:1. Hence the universe did not come by chance, and it is not eternal.

CHAPTER TWO

STUDIES IN CELESTIAL ARITHMETIC

1. *The Moon.* Our nearest neighbor, and the most interesting object in the sky to people on the earth, except the sun.

(1) Its diameter is 2163 miles; its volume is about $1/50$ that of the earth

while in mass it would take 81 moons to make an earth. The pull of gravity on its surface is only $1/6$ of what it is on the earth. Its sidereal revolution covers about $27\frac{1}{3}$ days, while its synodic period is about $29\frac{1}{2}$ days.

(2) It turns on its axis once while traveling around the earth and hence keeps the same face towards us continually.

(3) Its average distance from the earth is about 240,000 miles, and an express train traveling at 60 miles per hour could go to the moon and back in 11 months. A round trip ticket at 3c a mile would cost \$14,400.

(4) One of the highest mountains on the moon is called Leibnitz, and is fully 6 miles high. The surface of the moon contains several thousand craters and some of these are from 14 to 100 miles across. Copernicus, one of its great craters, is fully 13,000 feet high. The mountains of the moon are much higher in proportion than those upon the earth.

(5) The moon in its revolution around the earth travels at the rate of 3355 feet per second, 38 miles per minute, 2288 miles per hour, and completes a revolution around the earth in $27\frac{1}{3}$ days. It travels from west to

east and covers about 13° on the face of the sky daily. It would take more than 600,000 full moons to equal the light of the sun as it shines upon the earth.

(6) If a person should stand on the moon and look at the earth, it would look 14 times as large as the moon looks to us upon the earth. While it takes nearly 50 moons in volume to equal the earth, it takes more than 60,000,000 moons to equal the sun. While it takes 81 moons to weigh as much as the earth, it takes 26,892,000 moons to weigh as much as the sun.

2. *The Sun.* To us he is the most magnificent of all the heavenly bodies.

(1) His distance is 93,000,000 miles from the earth. A passenger train running 30 miles per hour would require 352 years to make a journey to the sun, and a round trip ticket at 3c a mile would cost \$5,580,000. Preachers traveling at half fare would have to pay \$2,790,000. A cannon ball traveling at 1760 feet per second would require nearly 9 years to reach the sun.

(2) The sun and moon appear about the same size, but if the sun could be brought as near the earth as the moon, it would seem to us as large as 160,000 moons, resulting in practically no night,

for it would fill the whole heavens. Furthermore, the earth would be 160,000 times as hot as it is now, and nothing could live upon it for a moment.

(3) The amount of light and heat given off by the sun has been calculated. The annual amount of heat received by the earth is sufficient to melt a layer of ice over its entire surface 114 feet thick; but the amount the earth receives must be multiplied by 2,170,000,000 to get the whole amount of solar radiation for the same time—one year.

(4) The sun is 750 times greater than all the planets combined—, the 8 larger planets, nearly 600 asteroids and 26 moons. If we should represent the earth by a marble one inch in diameter, the sun would be represented by a ball nine feet in diameter, and on this scale the earth would be 968 feet from the sun. On the same scale, Neptune would be $5\frac{1}{2}$ miles away, and the nearest star would be 49,500 miles distant, while Polaris would be at least 495,000 miles away.

(5) To get a better idea of the vast volume of the sun, remember that it is 866,000 miles in diameter which is 109 times that of the earth's diameter; its surface is 12,000 times that of the

earth; while its volume is 1,300,000 times that of the earth. Its mass is 332,000 times that of the earth. While its density is only one-fourth as much as the earth's, its superficial gravity is 27.6 times greater than that of the earth. In other words a body weighing 100 pounds on the earth would weigh 2760 pounds if carried to the surface of the sun. If an aeroplane could circle the earth in 10 days it would require 3 years for it to circle the sun.

If the earth were as large as the sun, and all objects on the earth were correspondingly as large, a man 6 feet tall would be increased to one-eighth of a mile; his arms from his shoulders to the tips of his fingers would be more than 160 feet long; his legs would be more than 250 feet long; his eyes would be 9 feet in diameter, while his nose would be about 14 feet long. The Mississippi River would be 140,000 miles long, and at Memphis, Tenn., it would be 109 miles across; Pike's Peak would be 292 miles high, while mount Everest would be over 500 miles above sea level. The Atlantic Ocean would be 327,000 miles wide, and from one side of Chicago to the other would be

more than 2000 miles. A train of cars containing 10 coaches would be more than 8 miles long.

CHAPTER THREE

THE BIGNESS OF THE SOLAR SYSTEM

The Ptolemaic system of astronomy gave way about the time of the discovery of the new world by Columbus. The Copernican system then came into popular favor. It was shown and proved that the diurnal movement of the heavens was due to the rotation of the earth on its axis. Real and apparent motion were pointed out and explained by Copernicus. The earth was given its true position in the universe, with the sun as the center of the solar system. A family of 8 larger planets and nearly 600 asteroids have been found to revolve around the sun in regular times and at definite distances.

But before the year 1781 it was not known that there were any planets beyond the orbit of *Saturn*. While the first real telescope was invented and used by Galileo in 1610, no new planet was discovered till 171 years later when *Uranus* was discovered in 1781 A. D. by the great astronomer Herschel. It

was found by accident and with a relatively small telescope of 7-foot length. This leads me to say that small telescopes have been used in the past and may be used in the future in making important discoveries. The instrument that found the 4 larger moons of Jupiter was a 30-inch instrument. Do not despise the small glass. Secure one for your own use if possible and use it industriously and enthusiastically. It will repay you many times in both pleasure and profit.

But I am digressing. Let us get back to Herschel and the planet Uranus. Anciently and up till 1781, Saturn was considered the outside planet of the solar system. This planet revolves around the sun at a distance of 886,000,000 miles from him. Double these figures and you have the dimensions of the solar system as known at that time. It will be 1,772,000,000 miles and represents the diameter of Saturn's orbit. But an hour or two before midnight of March 13, 1781 the solar system was suddenly doubled, and Wm. Herschel was suddenly made famous. His small telescope had done the work. He was industriously looking for other objects, searching among some stars in the constellation of Gemini when

the discovery was made. The dimensions of the solar system were thus doubled, for Uranus' orbit was found to be about double that of Saturn's, 1,800,000,000 miles from the sun. This was a great triumph and created much attention and excitement among astronomers. The study of astronomy became popular, telescopes were in demand and everybody wanted one.

Thus Wm. Herschel was brought out of obscurity into universal popularity and renown. Not only so, but he was lifted from poverty and inconvenience into favor and influence in many ways. Remember that Herschel by industry and perseverance became one of the world's greatest astronomers in the face of seemingly insurmountable obstacles. He was without a university education, but he made up for this by diligence, hard work, enthusiasm and a perseverance that conquered all difficulties. He learned to grind lenses and build telescopes, and after the discovery of Uranus the king gave him the means to build his great 40-ft. reflector. This was the crowning work of his life, for with it he penetrated into space and found stars of the 18th magnitude and so far away that it takes their light thousands

of years to reach the human eye. He became a Fellow of the Royal Society, was given an observatory by the king and received a salary of \$1000 a year, which was quite respectable in those days. But back to Uranus again. This planet is just about at the limits of visibility to the unaided eye, though it is 32,000 miles in diameter and fully 64 times as large as the earth. It makes a journey around the sun in nearly 84 years traveling at the rate of $4\frac{1}{2}$ miles per second. A child is born, it passes its youth into young manhood, then into married life, middle life, old age and dies at the age of 84 while Uranus makes one revolution around the sun. But it is never tired. It goes on and on and on.

The planet Uranus is so far away from the earth at its nearest approach that a limited fast-line express train running 1000 miles a day would require more than 4600 years to span the distance.

But 65 years after the discovery of Uranus, the diameter of the solar system was extended 2,000,000,000 miles. On Sept. 23, 1846 the planet *Neptune* was discovered. It was not found by accident as Uranus had been, but its discovery came about because two men

searched for it and calculated its place in the heavens, though the planet was invisible. One of these men was Leverrier of France, the other was Adams, an English astronomer. These men spent nearly two years making their drawings and calculations to find the place in the sky where the planet was believed to be. It is remarkable that neither of these men knew that the other was making calculations to find an unknown planet. But the result of their calculations almost agreed. These men did not, and could not, know that there was another planet farther out than Uranus, by means of their natural eyes; but they did know or strongly believed through their mathematical eyes that there was such a planet. Hence their search by means of two years of laborious calculations. It was the behavior of Uranus that led them to believe there was another planet outside his orbit. They could see an invisible body pulling on Uranus, disturbing him in his journey around the sun, hastening him or holding him back in certain portions of his orbit. They therefore prepared to find the unknown body. After the drawings and calculations were all completed, Leverrier requested the astron-

omer Galle to direct the telescope to a certain point in the constellation of Aquarius, and he would find the unknown body. It was found within a half hour and within less than a degree of the place where Leverrier said it would be. This discovery is regarded as one of the greatest mathematical achievements of the human mind. Such feats as this strengthen and confirm our faith in the mathematics of the heavens. And now since Neptune has been found, what are the great mathematical lessons forced upon our minds? This brings the dimensions of the solar system to twice the distance of Neptune from the sun. Neptune's distance being 2,800,000,000 miles from the sun, the diameter of his orbit is 5,600,000,000 miles. He circles the sun in nearly 165 years, and travels in an orbit $3\frac{1}{7}$ times the diameter of his orbit, at the rate of $3\frac{1}{3}$ miles per second. His distance from the sun is so vast that the light of the sun requires 4 hours and 10 minutes to reach Neptune. Now remember that light travels through space at the inconceivable rate of 186,000 miles per second.

In order to get perhaps a clearer idea of the meaning of this distance, con-

sider the following illustration. Sound travels through the air at the rate of 1090 feet per second. Suppose there is an explosion on the sun, and suppose that the sound of this explosion could be carried through space at the same rate of 1090 per second till it reached the planet Neptune. It would require more than 430 years for the report of the explosion to be heard on Neptune.

Another illustration. Suppose that aeroplanes were used away back in Old Testament times, and one of these machines actually started from the earth to the planet Neptune via the intervening planets—, Mars, Jupiter, Saturn, and Uranus, passing them in regular order, but never making a stop at any one of them. Suppose the machine started from the earth in the days of Judges, in 1170 B. C., near the time of Jephthah, the 9th judge, (Judges 11th chap.), and traveled all the way at 100 miles per hour, or 2400 miles per day. The first part of the journey was from the earth to Mars, a distance of 48,500,000 miles when that planet is nearest the earth. It required 55 years and passed the planet Mars, therefore, in 1115 B. C., within a few years of the death of Samson. The

second part of the journey was from Mars to the planet Jupiter, a distance of 342,000,000 miles. This part of the journey required 390 years and it passed Jupiter in 725 B. C., four years before Shalmanezzer carried the ten tribes into captivity. The third part of the journey was from Jupiter to the planet Saturn, a distance of 403,000,000 miles. It required 460 years and passed Saturn in 265 B. C. within a few years of the date when the Septuagint version of the Old Testament was made. The fourth part of the journey was from Saturn to the planet Uranus, a distance of 914,000,000 miles. The time required was 1043 years and it passed Uranus in 778 A. D., the year in which Charlemagne made an invasion of Spain and annexed the country between the Ebro and the Pyrenees under the name of the "Spanish March." The fifth part of the journey was from Uranus to the planet Neptune, a distance of 1,000,000,000 miles. It required 1142 years and arrived on the planet Neptune in A. D. 1920, this present year of grace. In other words, the distance from the earth to Neptune (2,707,000,000 miles) is so vast that the aeroplane which started from the earth to Neptune in

the year B. C. 1170, traveling constantly night and day at the rate of 100 miles per hour, finished the excursion at the completion of 3090 years, arriving on Neptune in 1920 A. D.

CHAPTER FOUR WEIGHT OF THE SUN AND PLANETS

The amount of matter in each planet and moon of the solar system as well as that of the sun himself has been calculated. In other words, each one of these bodies has been weighed. And this is one of the most wonderful achievements that astronomers have been able to accomplish. The problem of finding their weight, or of finding the amount of matter in each, is really a very difficult task. Yet the problem has been solved and the principle on which it has been done is as simple as that which has been used in finding their dimensions. The following figures express the weight of the earth in tons: 6,000,000,000,000,000,000, or six sextillion tons. Of course these figures are meaningless to us because the mind cannot grasp so stupendous a number, yet they represent the amount of matter which the earth contains. To find the weight of the sun, multiply the earth's

weight by 332,000, because the sun contains 332,000 times as much material as the earth.

Comparing the sun with the other planets we have the following: It takes 27,000,000 moons to weigh as much as the sun; 7,000,000 Mercuries; 407,000 worlds like Venus to equal the weight of the sun; 3,000,000 bodies like Mars; 1048 Jupiters; 3502 Saturns; 22,760 worlds like Uranus; and 19,500 Neptunes to weigh as much as the sun.

Comparing the earth with the other planets we have the following: It takes nearly 82 moons to equal the earth in weight; 21 Mercuries; Venus weighs $8/10$ as much as the earth; it takes 9 worlds like Mars to weigh as much as the earth; it takes 317 earths to weight as much as Jupiter; 95 earths to weigh as much as Saturn; $14\frac{1}{2}$ earths to equal Uranus in weight; and 17 earths to weigh as much as Neptune.

Now remember as has been stated before that the sun is 750 times as great as all the planets and moons of the solar system combined. Is it any wonder, then, that the sun has such tremendous pulling power, holding all the planets in their orbits and compelling them to revolve around him?

Is it any wonder that he has the power to reach out and take hold of far-away Neptune, 2,800,000,000 miles distant, and say to him, you may continue to travel around me, but you shall not get any further away? Remember, that while Neptune is 32,000 miles in diameter, it takes 19,500 Neptunes to weigh as much as the sun. But this is not all. The sun's power of attraction does not stop with Neptune. There are a number of comets that go out into space hundreds of times the distance of Neptune, and in every part of their journey they are under the influence and power of the sun's attraction. They go on journeys of hundreds or even thousands of years, but they are compelled by the superiority of the sun to return.

CHAPTER FIVE

ALPHA CENTAURI AND ITS MATHEMATICAL LESSONS

The four preceding chapters have been devoted mainly to the sun and his family, and we have been led to get a view of the vast dimensions of our solar system, expressed by the awful grasp of figures that tell us of its boundary. While the outer planet of this system is at the inconceivable

distance of 2,800,000,000 miles from the sun this distance is but a step, a mile, a measuring unit so to speak as compared with the vastness of the great void separating us from the nearest fixed star. When we have covered the space from the sun to the orbit of Neptune, we have just arrived at the front gate of our own premises, getting ready to start toward Alpha Centauri. This is a first magnitude star in the southern heavens and cannot be seen in this country except in the southern portion of the Gulf states. It is situated in right ascension 14 hrs. 32 mi., and 60d 25m southern Declination. It is a double star, and its components revolve around their common center of gravity at a mean distance of almost 25 times the radius of the earth's orbit, or 2,325,000,000 miles. The period of this binary system is 81 years. It is a great light-giving sun, and believed to be a little larger than our own sun. At any rate it is fully equal to it in luminosity.

But what can be said of the enormous distance of Alpha Centauri from us? How are we to get any idea of what is meant by 25,500,000,000,000 miles? This distance is so vast that light traveling through space at the

rate of 186,000 miles per second would require $4\frac{1}{2}$ years to span it. But this does not satisfy us and we must try another illustration. This star is 9000 time the distance of Neptune from us, and we found in a preceding chapter that an aeroplane traveling at 100 miles per hour would spend 3090 years in going from the earth to the planet Neptune. We must therefore, multiply 3090 by 9000 in order to find how long it would take the aeroplane to travel from the earth to Alpha Centauri. You will probably be asstonished to find by calculation that the time will be 27,810,000 years. Let us try another. We consider that sound is traveling at a rapid rate when it covers 1090 feet in a second of time, but at this rate if sound could be carried through space, it would require more than 3,000,000 years to travel from the earth to Alpha Centauri.

Here is another illustration. The Alpha star in the Centaur is in motion traveling through space at 14 miles per second. Let us suppose it is coming towards us at that rate, and will continue to come in this direction till it reaches the solar system. How long will it take? Dividing the distance to Alpha star by 14, the result will be

seconds; divide this by 60 and the result will be minutes; divide this by 60 and the result will be hours; divide this by 24 and the result will be days; divide this by 365 and the result will be years. You will find that it will require more than 57,000 years for the star to reach this part of the universe.

Still another illustration. Suppose a passenger train starts from the earth to Alpha Centauri, traveling continually and making 1 mile per minute. How long will it take to reach the star? By performing the calculation you will find that 48,200,000 years will be required. Now suppose that a ticket on this excursion one way costs 1c per mile, what will be the fare to the star? The fare will be \$255,000,000,000, as much as the great world war cost during the 4 years and 3 months it was running. Suppose the money for this ticket was put into standard silver dollars and piled one upon another, how far above the surface of the earth would the top dollar be? as it takes nine silver dollars to make an inch divide by 9 and reduce the inches to miles. The dollar on top of the column would be 445,000 miles high. It would reach to the moon and 207,000 miles beyond. It would make a string

of dollars all around the world 18 times, these dollars hugging each other as closely as it is possible for them to be.

CHAPTER SIX

ANOTHER LESSON IN STAR DISTANCES

It was not until 1838, that the distance to a single star was known. Astronomers had been for years trying to solve the problem. But in that year the distance to 61 *Cygni* was found to be about 8 light years from the solar system. It was the first star whose distance was measured. This star is found in the constellation of Cygnus, in Right Ascension 21 hr. 2 m. and 38d 15m Northern Declination. It is a few degrees southeast from the first magnitude star Deneb, and about 36d due east from Vega, a first magnitude star in Lyra. It is also about 40d northeast from Altair in the constellation of Aquila. Only two stars are known to be closer to the sun than 61 *Cygni*, and its distance is nearly 48,000,000,000,000 miles. If you should attempt to count 48 trillions at the rate of 1 every second, and should succeed in the attempt, you would have to live more than 1,500,000 years,

counting day and night. You would have no time to eat or sleep, but would be compelled to put in every moment of your time counting, if you finished the job in the above mentioned time. While this star is among the nearest to us, there is another one without a name of its own, but known as *Lalande* 21,185 that is a little nearer. It is a little under 7 light years away. The French astronomer Lalande numbered it 21,185 in his catalogue of stars. This explains why it is so called. It is located in Right Ascension 10 hr. 58 m. and 36d 38m Northern Declination. This leads us to say that there are about 800,000 different stars appearing in the various catalogues of stars now published. So that every star found with a 3-inch telescope can be observed and indentified, excepting of course those in the Milky Way.

The astronomer Lalande as mentioned above contributed greatly to the general progress of astronomical science and in 1895 was appointed Director of the Paris Observatory. He published an important work entitled, "Treatise on Astronomy."

CHAPTER SEVEN

THE UNFIXEDNESS OF THE FIXED STARS

Evidences of change are everywhere. Nothing is at rest. In the whole universe consisting of millions of stars, planets, comets, etc., there is not a single really fixed object. The term "fixed star" is only a paradox, and the stars appear to be fixed because of their enormous remoteness and the shortness of time in which we can observe them. The longest life of man is so short that to the untrained eye, the stars have seemed not to change. The fact is the stars are at such vast distances, that during a thousand years they would not have seemed to change their relative positions. But modern astronomical instruments prove that they are in motion. Halley an English astronomer discovered early in the eighteenth century that both Arcturus and Sirius have changed their positions in the sky during a few hundred years previous to that time, having moved in a southerly direction, Arcturus about one degree and Sirius a half degree. It is known that Arcturus is one of the large bodies in the universe, many times larger than the sun;

that it is speeding through space at a frightful rate, probably 200 miles or more per second; and yet it would take 800 years for it to pass over a space on the face of the sky equal to the diameter of the moon. How vast then must be its distance from us!

You will also find that the planets seem to be fixed if you observe them only one night, and those farthest out from the sun do not seem to change their positions except after many observations have been taken. For example, the planet Neptune moves eastward but little more than 2 degrees during a whole year.

In course of time the beautiful constellations that now adorn the sky will be pulled apart; the "Bands of Orion will be loosed"; the symmetrical big dipper will be torn to pieces; and the whole face of the sky will be changed. Time will bring this about, and it is sure to come. These changes are all so many evidences of life and activity in every part of the universe, and of the influence of the law of gravity by which the Creator is upholding and governing it.

CHAPTER EIGHT

THE SUN AND HIS FAMILY MIGRATING

Not only are the stars, planets and comets moving rapidly through space, but our own sun is in actual motion, speeding along with a velocity forty times as great as that of the swiftest cannon ball. Sometimes people reflecting on this are constrained to ask the question: "If this is true, are we not in great danger of running up against another great sun or a planet, or a comet, or some other object somewhere in space?" This leads me to say that our own sun and his attendants occupy a vast field, surrounded by a great void containing only meteors, bolides and comets. A large number of comets belong to, and are a part of, the solar system. That is to say, they are physically connected with the sun, and no difference how far they may recede from him they will be compelled to return into perihelion after a period of hundreds or even thousands of years. But there are also doubtless a number of comets that visit us once, and then go away never to return. But it is generally believed by astronomers, and there seem to be many evidences of the fact, that there are no large

bodies nearer to us than the great Alpha star in the Centaur, to which I called your attention in a previous chapter. This star is at least 277,000 times as far from us as we are from the sun, or as previously stated, about 9000 times the distance of Neptune from the sun, which is about $25\frac{1}{2}$ trillions of miles, or $4\frac{1}{2}$ light years away. This distance is so vast that if we could stand on the great Alpha star in the Centaur and look at the sun, it would appear about like Polaris does to us here upon the earth, and the most powerful telescope ever constructed would not have sufficient penetrating power to reach a single one of our planets, not even Jupiter, as large as he is.

It appears evident that there are no great bodies very near us and the solar system is in the midst of a great field in space, with a diameter of at least 50 trillions of miles across. In other words, it would take light 9 years to travel from one side of this vast field to the other. Now as stated at the head of this chapter, the sun is in motion, he is actually migrating, or on a journey. It is also known that he is moving at the rate of about 11 miles per second. If the sun should

travel at this rate immediately towards the nearest star, the journey would require more than 70,000 years. So it appears that we are in no immediate danger of colliding with another great sun. As the sun is speeding through space at about 11 miles per second, attended by his planets and comets, he is covering nearly 350,000,000 miles annually. If Adam lived 6000 years ago, the sun and his family have covered only 2,100,000,000,000 miles since his day, which is only about one-twelfth of the distance to Alpha Centauri.

CHAPTER NINE

THE PLEIADES

This beautiful and well known cluster is often called the seven stars. It was observed and recorded in very ancient times, and concerning it we find the following in the book of Job: "Which maketh Anturus, Orion, and Pleiades, and the Chamber's of the South", Job 9:9; "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion"? Job 38:31. We also find the following reference to it in the prophecy of Amos 5:8: "Seek him that maketh the Seven Stars and Orion, and turneth the shadow of death into morning." Homer also re-

fers to this group. Here we have evidence of the fact that the ancients studied the heavens, and were to some extent acquainted with the constellations and prominent objects in the skies. The Pleiades appear in the constellation of Taurus and are easily distinguished to the northwest of Orion and Aldebaran. They are in Right Ascension 3 hr. 42 m. and 23d 50m Northern Declination. A person with good eyes can see six stars, while very strong eyes can see three others.

The most brilliant of the nine is Alcyone a third magnitude star; Electra and Atlas are of the fourth; Maia, Merope and Taygeta are of the fifth; while the three not easily seen with the naked eye Pleione, Calaeno and Asterope are of the sixth magnitude. As six are easily visible to the naked eye and formerly, the Latin poet tells us, seven were counted, these facts may be held to prove that one of them is variable, and has diminished in brightness, or else has disappeared.

The moon sometimes comes between us and the Pleiades. It did so July 23, 1897. The mathematics of the heavens is so exact that the astronomer can look forward and foretell the day, hour and minute for a hundred or

even a thousand years in advance, that such an event will occur. He can also calculate backward and tell when such an event actually occurred in the past.

While the naked eye can see six or seven stars in the Pleiades, a small telescope brings out probably fifty; large telescopes with photograph-plate after several hours of exposure, bring to view fully 2326 stars. How wonderful that so small a space on the face of the sky contains so large a number!

Astronomers have been laboring diligently since 1838 when the first star was measured, to find the distance of the Pleiades. The conclusion arrived at by Newcomb and others is, that Alcyone, the brightest star in the Pleiades, is 267 light years from the solar system. If we could look at the sun at such a distance, we would be compelled to use a telescope, for it would appear as a ninth magnitude star, and therefore would be invisible to the unaided eye. Alcyone is estimated to radiate about 250 times as much light as the sun. That being true, vast must be the dimensions of that great sun.

CHAPTER TEN. GREAT SUNS OF THE UNIVERSE.

1. *Sirius*.

This is the brightest star in the heavens. It is the alpha star in the constellation of Canis Major, or the Great Dog. It is found in Right Ascension 6 hours and 40 minutes, and 16 degrees and 34 minute Southern Declination. It is approaching the earth at the rate of about ten miles per second. It is really overtaking the solar system, for the sun with his family of planets and moons is traveling towards that part of the heavens opposite to Sirius. Its distance from us is so vast that the light of Sirius requires $8\frac{1}{2}$ years to come to us. This means that it is at least 50,000,000,000,000 miles away. There are only two or three stars known to be nearer to us than Sirius. While this great sun is really considered among our nearest neighbors, it is about twice as far away as Alpha Centauri, or 550,000 times the earth's distance from the sun. Stated in other words, the great Dog Star is situated in space at a distance 18,000 times as far from the sun as is the planet Neptune. As Sirius is known to be traveling towards the solar system at 10 miles per second,

the question has been asked: "How long at this rate will it take for the star to overtake us?" By a little calculation in long division it is found that it will require more than 158,000 years; so there seems to be no cause for worrying about any immediate danger here.

This great sun attracted much attention in ancient times, so that from Homer on down, nearly all the poets referred to it. Sirius rises about ten o'clock in the middle of November of each year, and is above the horizon only about 10 hours. On January 1, it rises about half past eight P. M. On the 28th of January it is in the opposite part of the heavens from the sun, and rises about the time the sun sets, which is about 5 o'clock. So it is really a beautiful winter star, and is still very attractive during March and April. Early in May it becomes lost in the brilliancy of the sun, and sets with the sun on the 20th of that month.

Considering the distance and brightness of this star, it has been estimated to be at least 100 times as large as our sun. It has a very interesting companion which was discovered by A. G. Clark, the great telescope maker

of Cambridge, Mass. in 1862. He discovered it with an 18-inch telescope. Sirius and its companion revolve around their common center of gravity in about 50 years, at a distance of about 1,800,000,000 miles, which is about the same distance of Uranus from the sun.

2. *Vega*.

Beautiful Vega is fourth in the order of brightness of all stars of the first magnitude, and is the most prominent star in the constellation called the Lyre. It is situated in Right Ascension 18 hr. 34 mi., and 38 degrees 42 minutes Northern Declination. It is on the opposite side of Polaris from Capella. The star is about 7 degrees farther South than Capella, but some 20 degrees farther North than Arcturus. It can be seen in the latitude of Minneapolis at some time during every night in the year; if not early in the evening, then it can be observed during the morning hours of the same night. It is about 50 degrees from Polaris. The sun at Vega's distance would not be more than one-ninetieth as bright as Vega. Astronomers have estimated that the total light of all the stars is about equal to 750 Vegas. It is a bluish-white star, very beautiful, and

through a telescope it has the brilliancy of an electric arc light, and for this reason it is sometimes called the "Arc-Light of the sky." It is a hydrogen star very much like Sirius's, but differs from it in showing a small amount of helium. It is found near the Milky Way. Vega, Arcturus and Capella are nearly equal in brightness, but Vega is generally regarded as the brightest of the three.

Vega is more than 21 light years from us, or about $2\frac{1}{2}$ times as far away as Sirius, and this means that it is at least 126 trillions of miles distant. Remember that a light year is the distance a wave of light will travel in one year at the rate of 186,000 miles per second, and amounts to nearly 6,000,000,000,000 miles. Vega is one of the very large sun's of the universe and gives out fully 90 times as much light as the sun.

The sun is moving almost in the direction of Vega, or to be more exact, it is moving towards a point in the sky about 5 degrees or 6 degrees from Vega. The relative rate of approach of the sun and Vega is about 10 miles per second, and at this rate it will take the sun 558,000 years to pass by Vega. Notwithstanding we are

traveling nearly in the direction of this star at present, we really will never pass very near it.

While Vega is now nearly 51 degrees from the North Celestial pole, 12,000 years hence it will be only $4\frac{1}{2}$ degrees from the pole, and then it will be our pole star.

From May on through the summer Vega is the most beautiful and attractive star in the evening sky. Early in May it rises as the sun is setting and therefore it shines all night. During July and August it is almost overhead in our latitude from 9 to 10 o'clock, and receives the attention and comments of star gazer's generally. In the month of November it sets somewhere about 1 o'clock at night, and in January about 9 P. M.

Herschel proved mathematically that if Vega should be removed 10 times its present distance from the sun (at which time it would be more than 210 light years distant), it would be a star of the sixth magnitude, and would then only be just visible to the unaided eye. If it should be removed 100 times its present distance, it could still be seen with moderate telescopes. If it should plunge into space 1,000 times its present distance or 21,000

light years, it would still be visible in the largest telescopes.

3. *Aldebaran*.

This is one of the six very brilliant winter stars, and the other five are: Betelgeuse, Rigel, Pollux, Procyon, and Sirius. It is found in Right Ascension 4 hr. 31 m. and 16 degrees 20 minutes Northern Declination. It is indeed a great red sun, or star of the first magnitude, in the eye of Taurus, the Bull. It is the most brilliant star in the Hyades, which group is situated about 9 degrees Southeast of the Pleiades. This star is about 15 degrees Northwest from Betelgeuse, and about 35 degrees Northwest from Sirius. Considering these facts, and being a magnificent red star, it is not difficult to locate on the face of the sky. Of the first magnitude stars, Aldebaran is fourteenth in order of brilliancy. It has been estimated that the sun gives us 90,000,000,000 times as much light as this star, but if it were brought as close to us as the sun, it would give us 45 times as much light as we receive from the sun. It must therefore be many times larger than our sun. So vast is its distance from us that it requires 28 years for its light to reach the human eye, and this means that it

is nearly 168 trillions of miles away. The spectroscope shows that this star is speeding through space and away from the sun at the rate of 30 miles per second; but it must travel on at this rate for more than a thousand years before it will add another trillion of miles to its distance. Aldebaran rises about an hour after the Pleiades at which time it is almost directly under this group. It shows its bright red face in the evening sky for fully 8 months in the year. In the early days of October it rises between 9 and 10 o'clock P. M., and shines the remainder of the night. In the early part of December it rises about the time the sun is setting, and requires about 7 hours to reach the meridian. During the last days of May it becomes lost in the brilliancy of the sun, and during the month of July it rises and can be observed a short time before sunrise.

The moon many times in its passage through the heavens comes between us and Aldebaran, at which times of course the star is hid from our view. Astronomers can calculate ahead of time a year, or a thousand years as to that matter, just when a happening of this kind will occur. This is an-

other evidence of the exactness of astronomical mathematics.

CHAPTER ELEVEN. OTHER GREAT SUNS.

4. *Capella.*

Capella is a magnificent star of the first magnitude in Auriga, the Charioteer. It is about 40 degrees from the Big Dipper, situated a little more than half way from Polaris to Bellatrix, and is closer to Polaris than any other of the very bright stars. Its Right Ascension is the same as that of Rigel in Orion, being 5 hr. 10 m., and 45 degrees 54 minutes Northern Declination. Capella is a yellow star with golden rays, like our sun, and the spectroscope reveals the fact that there is vapor of iron, sodium and many other metals in its composition. It is a spectroscopic binary. While Capella is one of the comparatively near stars to the solar system, it is really a little more than 34 light years distant, or over 200 trillions of miles away. This means that it is 4 times the distance of Sirius, and 72,000 times Neptune's distance from the sun. The sun at its distance would be at about the

limits of visibility without the use of a telescope.

Should Capella be brought as near to us as the sun, it would be 60 times as bright as he is. It is really receding from us at the rate of about 15 miles per second, 900 miles per minute, 54,000 miles per hour, or more than a million miles per day. It has been calculated to radiate more than 200 times as much light as the sun, but it is believed to have lost some of its luminosity within the past few years. This star being situated more than half the distance from the celestial equator to the North Pole is above the horizon fully 20 hours out of every 24. In other words, from the time it sets till it rises again is only about 4 hours, and for this reason it can be seen at some time during the night of every month in the year. Early in August it rises about 10 o'clock at night and shines the remainder of the night. During July it is too close to the sun to be viewed with satisfaction, but in the month of October it rises about the time the sun is setting and therefore shines all night. While Capella appears to the naked eye to be a single star, it is really a great spectroscopic binary system, and its companion lies so

near to it that they revolve around their common center of gravity in about 104 days.

5. *Arcturus*.

"Canst thou guide Arcturus with his sons?" Job. 38:32. "Which maketh Arcturus, Orion and Pleiades, and the Chambers of the South." Job. 9:9. Job must have been something of an astronomer, although he lived in the earliest days of authentic history. This is a magnificent star of the first magnitude in the constellation of Boötes, the Bear Driver, and is situated in the left knee. It is found in Right Ascension 14 hr. 12 m., and 19 degrees 39 minute's Northern Declination. With Denebola and Spica it forms a large equilateral triangle. It is not difficult to locate in the heavens for the handle of the Big Dipper when prolonged with a continuation of the curve which it possesses leads to Arcturus. No other very bright star is near it.

It is one of the great suns of the universe, and is often called a "run-away star," because it is known to be speeding through space at a prodigious rate, probably not less than 200 miles per second, or more than 17,000,000 miles per day. But its distance from

us is so vast that a century would be required for it to pass over a space on the face of the sky equal to one-eighth the diameter of the moon.

It outshines any other star in the Northern heavens unless it be Capella. There is a rivalry between Capella, Arcturus and Vega as to brightness, but those who have given most attention to the subject have concluded that Capella is the most luminous of the three. Arcturus is at least 12 times as far away as Sirius, and still more vast in its dimensions, for its bulk is believed to be at least 3,000 times that of the latter star. Its great luminosity and the vastness of its distance are proofs of its ponderous size. Its spectrum closely resembles that of the sun, and not less than 100 years are required for its light to come to us. Its light-giving power is equal to that of perhaps 1,300 suns such as ours.

Arcturus is about 20 degrees southwest of the constellation, Corona Borealis. In the early nights of March it rises about 8 o'clock, while on April first it comes up about the time the sun is setting and of course shines all night. In order that you may keep along well with its position in the sky and know where it is, you will find

it almost overhead early in the night June 15 and it slowly floats towards the northwest during July.

If our sun were as distant as is Arcturus, it would really be a telescopic object because it could be seen only through a telescope, entirely invisible to the unaided eye.

CHAPTER TWELVE.

CANOPUS THE GREAT SOUTHERN STAR.

Of the five very beautiful first magnitude stars too far south for observation in our latitude, the names of which being Alpha Centuari, Beta Centauri, Alpha Crucis, Achernar, and Canopus, the latter can be seen in southern Florida and Texas for a short time only as it does not remain above the horizon long at a time. All of them are visible from the West Indies southward.

Canopus is known as the great star of prehistoric Egypt, and brightest of the entire heavens except Sirius. It is situated in Right Ascension 6 hr. 22 m., and 52 degrees 39 minutes Southern Declination. It is therefore less than 38 degrees from the South Celestial pole. It yields no appreciable parallax as it has no appreciable proper motion.

It seems to be situated among stars of the eight magnitude if not farther. It must for this reason have at least 10,000 times the light-giving power of the sun. At this distance the sun would long have ceased to be visible to the naked eye. As Canopus is a solar type of a star, its density and temperature must be somewhere near the sun's. If the luminosity of Canopus is 10,000 times that of the sun, it follows that its diameter is at least 100 times the sun's, because the surfaces of globes are to each other as the squares of their diameters. Canopus is without doubt one of the greatest bodies in the universe known to astronomers, and believed from the above reasons and from many other facts to be at least 1,000,000 times larger than the sun. The volumes of globes are to each other as the cubes of their diameters. If the diameter of Canopus is 100 times that of the sun, then its volume is 1,000,000 times that of the sun. We learned in Chapter Two that the volume of the sun is 1,300,000 times that of the earth. That being true, the volume of Canopus is 1,300,000,000,000 times that of the earth.

Great as Arcturus is, it is probable that Canopus is at least 300 times

greater. While Canopus yields practically no parallax and its distance has not therefore been measured by that means, yet for various other reasons it seems evident that it is at the least estimate 310 light years from the solar system. This means that this great southern sun is 1,860 trillions of miles away, or expressed in other figures it is about 20,000,000 times further from the earth than is the sun.

CHAPTER THIRTEEN.

REGULUS THE GREAT ECLIPTIC SUN.

This is called Cor Leonis, the Lion's Heart, and by astronomers Alpha Leonis. It is located in the Constellation, Leo, in Right Ascension 10 hr. 4 m. and 12 degrees 24 minutes Northern Declination. It is very nearly on the ecliptic being almost covered by the sun on the 20th of August as each year rolls around. It is many times hidden from our view by the moon, because that body in its revolution's around the earth comes between us and that sun.

Regulus is about 60 degrees a little North of West from Arcturus, and is easily recognized as the brightest star in

the Constellation. This star is of unusual interest because of the fact that the November Meteors, or the Leonids, seem to approach the earth from a point a few degrees North of it. While it is doubtless many times larger than Sirius, it has only $1/13$ of the brightness of that star, because of its vast distance from us.

Regulus is really a great telescopic triple, i. e. while the naked eye can see only one star, the telescope resolves it into 3 great suns. The position of Regulus was found by Babylonian astronomers upwards of 4,000 years ago. It was at that time in longitude 119 degrees, while it is now more than 148 degrees.

During the months of June and July Regulus can easily be found about 50 degrees a little North of West from the bright star, Spica, in the constellation Virgo, and at that time it will be low in the West. It can be observed in both winter and summer, and is really visible the first half of the night for about $2/3$ of the year. It rises at 9 P. M. during the last half of December, and continues to be the most conspicuous star in the eastern skies till the appearance of Vega and Arcturus a little later. Between 6 and

7 hours after it rises it reaches the meridian, at which time it is about 60 degrees above the horizon, and about 30 degrees from the zenith. During the first 3 months of the year it shines all night, and in the month of February it rises about the time the sun is setting. During the fall months of October and November, it shines beautifully in early morning hours.

Regulus is certainly one of the very great suns of the universe in dimensions, and is estimated to send out 1,000 times as much light as the sun. It must therefore be many thousands of times larger. Its distance from the earth is so vast that it requires 162 years for its light to come to us.

CHAPTER FOURTEEN.

POLARIS AND ITS MANY LESSONS.

Polaris, the brightest star in the constellation, Ursa Minor, The Little Bear, is located in Right Ascension 1 hr. 27 m. and 88 degrees 50 minutes Northern Declination. Polaris, Deneb and Vega form a right-angled triangle of which Deneb is in the right angle. This triangle is not difficult to find, and it is a splendid way to find the

North Star. A line drawn from the bright red star, Antares, about midway between Arcturus and Vega and continued till the entire length is 116 degrees will reach Polaris. Another way to find Polaris is to imagine a line drawn through the "pointers" of the Great Dipper and extended about 25 degrees from the nearest pointer to Polaris.

This star is the center of the Northern Stellar company of stars, and several beautiful constellations revolve around it every 24 hours, among them being Cassiopeia and the Big Dipper. This star is also the center of a circling system of its own. It travels around the North Celestial Pole in a very small circle of less than $2\frac{1}{2}$ degrees in diameter. In this circle are many invisible stars. More than 75 have been seen through telescopes, and fully 200 have been counted on photographic plates. There is a 9th magnitude star, therefore telescopic, almost exactly at the pole. Polaris is a double star, its companion is of about the 9th magnitude, and the spectroscope has revealed the fact that there are two almost dark companions revolving around Polaris. In reality it is a telescopic double, and the brighter

component of the double star is really a spectroscopic triple. So when we look at Polaris we really look at 4 stars, though apparently only one.

Remember that Polaris is estimated to be 44 light years from the solar system, and is really one of our nearest neighbors. Notwithstanding, if an aeroplane should start today to Polaris, traveling continuously night and day at 200 miles per hour, or 4,800 miles per day, it would require more than 150,000,000 years to make the journey. Let us use another illustration. Suppose we were connected with Polaris by telephone, and a message should be started today over the wire. It would be 44 years before it would be heard on Polaris, and another 44 years would be required to get a reply. We are supposing here that a message by electricity travels at the same rate of speed as light, viz., 186,000 miles per second.

On account of the precession of the equinoxes Polaris will not always be our pole star. The North Celestial pole is slowly approaching Polaris and in 2095 it will be within less than one-half degree from the star, at which time it will begin to recede, and in about 12,000 years Vega will be our

pole star. Then the pole will begin to recede from Vega and will continue to do so till after the lapse of another 12,000 years, when Polaris will again be our pole star.

CHAPTER FIFTEEN.

DENEB THE GREAT SUN IN CYGNUS.

The word Deneb comes from the Arabic. The catalogue name is Alpha Cygni, The Swan. It is a very beautiful white star, and is located in Right Ascension 20 hr. 38 m., and 44 degrees 57 minutes Northern Declination. It is in one of the finest of the constellations. This constellation may be easily recognized by the shape of a cross formed by its 5 principal stars, Deneb being the brightest and the most Northern. This constellation is noted because the first star whose distance to be measured is located in it. Its catalogue name is 61 Cygni. Its parallax was found and the star's distance was measured in 1838. It was found to be about 8 light years distant as stated in Chapter Six.

Deneb yields no appreciable parallax which is proof that the star is of vast distance from us. Its luminosity is so great that it must be many times

larger than the sun. When a star yields a parallax, its distance can be measured by that method. Otherwise its distance must be calculated in some other way. Upwards of 60 stars have yielded a parallax and their distances measured.

This star appears above the horizon about $19\frac{1}{2}$ hours from the time it rises till it sets. The great Northern Cross of which Deneb is a part covers about 20 degrees in the Milky Way.

Of the 20 first magnitude stars, Deneb is the lowest in apparent brightness, but it is likely among the largest in actual size. Its light-giving power must, therefore, be vast. Astronomers have announced that the star is approximately 325 light years from the solar system, or 1,950,000,000,000,000 miles. A canon ball traveling at the rate of 1,750 ft. per second would require nearly 185,000,000 years to span the distance.

Deneb is coming towards us at the rate of 30 miles per second, and if it continues to come at that rate, it will be 2,063,000 years before it arrives. As this star is above the horizon nearly $\frac{5}{6}$ of the time, it can be observed sometime between sunset and midnight during every night in the year.

While it shines with less brightness than the other first magnitude stars, it is very beautiful during January and February. It rises about the time the sun is setting in May, and shines all night. At the opposite end of the cross from Deneb is Albireo, which the telescope resolves into two stars. The components are about 35 seconds of a degree apart, appearing to the naked eye as only one star, but a small telescope easily shows the two.

CHAPTER SIXTEEN.

RIGEL THE GREAT ELECTRIC SUN OF ORION.

This beautiful Southern star is situated in one of the finest constellations in the Southern sky, if not in the entire heavens. It shows itself splendidly all through the winter months in the evening sky.

It is located in Right Ascension 5 hr. 10 m., and 8 degrees 18 minutes Southern Declination. It is a little more than 50 degrees exactly south of Capella, and about 20 degrees southwest of Betelgeuse. The Belt of Orion is situated nearly on the equator and about midway between Rigel and Betelgeuse.

Rigel is a first magnitude star and

has been found to be a telescopic double, both components being bluish-white in color. They are about 10 seconds of a degree apart. It is without doubt one of the great suns of the universe in point of size and light-giving power. From the proper motion of this star it is estimated to be at least 330 light years distant and this being true, its light-giving power must be at least 8,000 times that of the sun. As light travels nearly 6,000,000,000 of miles per year, in 330 years it would travel 1,980 trillions of miles, and this represents the distance to Rigel in miles. This distance is so vast, that the figures by which it is expressed, daze the mind. Therefore, when you are looking at Rigel you are beholding a star 700,000 times Neptune's distance from the sun; nearly 78 times the distance to the nearest fixed star; more than 11 times Vega's distance from the sun; and $7\frac{1}{2}$ times the distance of Polaris from our own great luminary.

The spectroscope reveals the fact that Rigel is receding from the solar system at the rate of 15 miles per second. If it continues to travel from us at this rate, to cover a distance representing only 1 per cent of

the present distance, it must spend 41,800 years.

CHAPTER SEVENTEEN.

THE SOLAR SYSTEM BOUND TOGETHER BY LAW.

The solar system is composed of the sun, 8 planets, nearly 600 asteroids, 26 moons, and a number of comets that go out into space and return periodically. Not a single member of the system is at rest. All are in motion, and certain laws govern these motions. The operation of a few beautiful laws, mathematically expressed, keep all these hundreds of bodies in motion and yet hold them in place, so that unity reigns and order and beauty are seen and observed in every part. The mathematics of the whole system is so well in hand, that the astronomer knows simply by looking at his chart where any of the members of the system are at any given time during the year.

We owe much if not *all* to such men as Kepler, Newton, Tycho Brahe, Galileo, etc., for our knowledge concerning these laws, and the perfect working of the system.

Let us keep in mind *Newton's Universal Law of Gravitation*: "Every

particle of matter in the universe attracts every other particle of matter with a force directly proportional to the product of their masses, and decreasing as the square of the distance between them increases."

It is by this law that the sun holds all his planets and periodic comets in place, and the planets hold all their respective satellites or moons in proper position. Some comets, for example, go out into space enormous distances from the sun, traveling for hundreds or even thousands of years, but by the universal law of gravitation they are compelled to return. As an illustration, Comet II of 1844 will travel away from the sun for 51,025 years reaching its aphelion distance at a point in space 143 times the distance of Neptune, or 4,366 times the earth's distance from the sun, in round numbers 400 billions of miles. But on account of the superiority of the sun (for he is 750 times greater than all his planets, asteroids and moons combined), this comet will be compelled to return, and it will require another 51,025 years for it to return in perihelion.

Let us also remember *Newton's First Law of Motion*: "A body once in mo-

tion would move forever in a straight line, if it were not acted on by some external force." By keeping these two laws in mind, we are able to understand why the planets and asteroids are not allowed by the sun to fly off into space, but are compelled to revolve around him at regular distances and definite times which are well known. These bodies already in motion would move in a straight line, according to the first law of motion, if it were not for the overruling power of the sun compelling them to travel in curved paths.

The sun is the great center of the system, 750 times greater than all the planets combined. They travel around the sun in almost perfect circles. The law is, the nearer a planet is to the sun, the faster it must travel to keep from being drawn to him. The law of universal gravitation explains the reason why that Mercury, the nearest planet to the sun travels at the rate of 30 miles per second, while Neptune, the outermost planet, travels at the rate of only $3\frac{1}{3}$ miles per second. If Mercury's rate were only $3\frac{1}{3}$ miles per second, it would be slowly but surely pulled to the sun. If Neptune's rate

were 30 miles per second, it would fly off into the infinite depths of space. The sun's pulling power at Neptune's distance is not near so great as it is at Mercury's distance, for by the law of universal gravitation as stated above, the attractive power of the sun "decreases as the square of the distance increases."

We find that there is a regular decrease in the rate of motion of all the planets from Mercury to Neptune, as follows:

1. Mercury is 36,000,000 miles from the sun, completes a revolution around that body in 88 days, and travels at the rate of 30 miles per second.

2. Venus is 67,000,000 miles from the sun, completes a revolution around him in nearly 225 days, and travels at the rate of 22 miles per second.

3. The earth is 93,000,000 miles from the sun, completes a revolution in 365 days, and travels at the rate of $18\frac{1}{2}$ mile per second.

4. Mars is 141,000,000 miles from the sun, completes a revolution in 687 days, and travels at 15 miles per second.

5. Jupiter is 483,000,000 miles distant from the sun, completes a revolution in nearly 12 years, and travels at about 8.1 miles per second.

6. Saturn is 886,000,000 miles from the sun, completes a revolution in about $29\frac{1}{2}$ years, and travels at 6 miles per second.

7. Uranus is 1,800,000,000 miles distant from the sun, completes a revolution in 84 years, and travels at 4.2 miles per second.

8. Neptune is 2,800,000,000 miles from the sun, completes a revolution in not quite 165 years, and travels at the rate of $3\frac{1}{3}$ miles per second.

The same laws hold good relative to the various planets in relation to their respective moons. There are known to be 26 moons in the solar system. The earth has 1; Mars has 2; Jupiter has 8; Saturn has 10; Uranus has 4; and Neptune has 1.

Our own moon is 238,840 miles from the earth, completes a revolution in 27 d. 7 hr. 43 m. 11s., and travels at the rate of about $\frac{2}{3}$ of a mile per second.

Mars' inner moon, (*Phobos*) is so near the planet, (5,850 miles) that it completes a revolution in 7 hr. 39 m. 15s., and travels at the rate of $1\frac{1}{3}$ miles per second. In other words it travels around Mars 3 times in about one of our days. While his outer moon, (*Deimos*) being about $2\frac{1}{2}$ times

as far away, (14,650 miles), completes a revolution in 1 d. 6 hr. 17 m. 54 s., and travels at the rate of only .9 of a mile per second.

Jupiter's nearest moon is 112,000 miles from the planet, completes a revolution in a little less than 12 hours, and travels at the rate of 14 miles per second; while his outermost moon is 7,403,000 miles distant (nearly 66 times as far from the planet as his innermost moon), completes a revolution in 265 days, and travels at the more moderate rate of a little more than 2 miles per second.

Saturn's innermost moon, (Mimas) is 117,000 miles from the planet, completes a revolution in 22 hr. 37 m. 5s., and travels at the rate of nearly 9 miles per second; while his outermost moon, (Phoebe) is 8,000,000 miles distant (more than 68 times as far from the planet as his innermost moon), completes a revolution in 546 days, and travels at the rate of a little more than 1 mile per second.

Uranus' nearest moon, (Ariel) is 120,000 miles distant, completes a revolution in a little more than $2\frac{1}{2}$ days, and travels at $2\frac{1}{2}$ miles per second; while his outermost moon, (Oberon) is 365,000 miles away, com-

pletes a revolution in 13 d. 11 hr. 7 m. 6s, and travels at nearly 2 miles per second.

Neptune's moon is 221,500 miles distant, completes a revolution in 5 d. 21 h. 2 m. 44 s., and travels at the rate of 2.7 miles per second.

We must also keep in mind *Kepler's Third Law*: "The squares of the times of revolution of the planets about the sun are proportional to the cubes of their mean distances from the sun."

This is a beautiful law, and is a convincing argument that nature is built on law and order. It is also positive proof that design and intelligence are back of all things and the *cause* of all things.

Under the word *Time* below will be found the number of years or fraction of a year that the planets require to revolve around the sun. Under the words *Mean Distance* will be found the figures representing the number of millions of miles that the planets are situated from the sun.

	<i>Time</i>	<i>Mean Distance</i>
The earth ..	1.00 year	93 mil. miles
Mercury	.24	36
Venus	.62	67
Mars	1.88	141
Jupiter	11.86	141

Saturn	 29.46	886
Uranus	 84.00	1800
Neptune	164.78	2800

Applying the above law, we can form a number of proportions, showing the beautiful mathematical relations of the planets to each other. The figures especially under *Mean Distance* are only approximate, not intended to be scientifically exact, but simply stated in round numbers.

We can use any pair of planets in forming the proportions. To illustrate:

The earth's time (1 year)² is to Mercury's time (.24 year)², as the earth's mean distance (93 million)³ is to Mercury's mean distance (36 millions)³.

Performing the operation, you will find that the product of the means will equal the product of the extremes, i. e. it will be approximately so.

In the same way you can use any two of the planets above with like results, by applying Kepler's Third Law.

Let us consider another example:

Suppose we know the earth's time and mean distance; we also know Uranus' time, but we do not know Uranus' mean distance. How can we find the mean distance? As follows:

1 squared is to 84 squared as 93 cubed is to x cubed.

We let x represent the unknown mean distance here. The product of the extremes being equal to the product of the means, x will be found to equal the cube root of 84 squared multiplied by the cube of 93. The result will be approximately 1800, which means 1800 millions of miles, approximately the distance from the sun to Uranus.

CHAPTER EIGHTEEN ALGOL THE GREAT VARIABLE SUN IN PERSEUS.

This famous Variable Star belongs to the Sirian type as its spectrum indicates. It seems to have been red hundreds of years ago, but now it is white, or slightly yellowish.

It is located in Right Ascension 3 h. 2 m., and 40 degrees and 34 minutes Northern Declination. It is a fixed star in Medusa's Head, in the constellation, Perseus, its catalogue name being Beta Persei. It is remarkable for its variation in brightness. The name Algol is Persian in origin, and means the "demon," which indicates that the ancients most likely observed some peculiarities in its behavior.

The periodical changes in its brightness seem to be the result of eclipses by a dark satellite, which comes between us and the star. The variability of Algol was discovered in 1667, by Montanari, but the English astronomer, Goodricke, was first to give a satisfactory explanation of its variability in 1782, now 138 years ago (this 1920).

In 1889, Vogel fully demonstrated by use of the spectroscope, that Algol is really a binary system, and is called a spectroscopic binary, with a dark companion revolving around it, whose plane passes nearly through the solar system.

Algol is usually a star of the second magnitude, but at regular intervals of 2d 20h 48m 54s it falls to nearly the fourth magnitude; it remains faint for only about 20 minutes, and then rekindles until it reaches its usual brightness. The variation of its light continues during 9 hrs. and 45 m. of each period.

Both components are in motion and both revolve around their common center of gravity of the pair. Vogel found by studying this star with the spectroscope, that a little before a minimum of light takes place, the dark companion is approaching us, and the

bright companion is receding. After the minimum of light is over, the motion of the two bodies is reversed, the bright one approaching us, and the dark companion receding. This is exactly as it should be in a system of this kind. The components seem to be about 3,230,000 miles apart, the diameter of Algol being estimated to be 1,000,000 miles, and that of its dark companion, 800,000 miles, nearly as large as the sun. Algol, the brighter of the two, is estimated to be at least fifteen times as bright as the sun.

While this star yields no parallax, it has been estimated to be not less than 23 light years from the sun, and this great system is approaching us.

Remember that this periodic variation in the brightness of Algol is regular, and astronomers can calculate for a hundred years ahead of time exactly when an eclipse will begin and end, as easily as they can an eclipse of the sun or moon. This is but another argument in favor of the exactness of astronomical mathematics.

CHAPTER NINETEEN
CASTOR AID POLLUX

"And after three months we departed in a ship of Alexandria, which had wintered in the isle, whose sign was Castor and Pollux." Acts. 28:11.

Anciently favorable navigation was believed to have been brought about by the influence of these stars, and the ship in which Paul sailed away from Melita bearing the sign of *Castor* and *Pollux* carried him safely on towards Rome.

These are the two brightest stars in the constellation Gemini. Pollux whose catalogue name is Beta Geminorum is at present the brighter of the two, and is the only first magnitude star to be found in the constellation. But three centuries ago this order of luminosity was reversed, and Castor outshone Pollux. These brothers are distant only about 4 or 5 degrees. Castor rises something like 20 to 25 minutes earlier than Pollux, both appearing at nearly the same time in which Rigel and Betelgeuse rise.

Gemini in which Castor and Pollux are located is one of the zodiacal constellations, and is on the opposite side of the Milky Way from Taurus and

Orion. The sun enters Gemini May 20th of each year.

Pollux is situated in Right Ascension 7 h 40 m and 28 degrees 15 minutes Northern Declination. Castor, or Alpha Geminorum is situated in Right Ascension 7 h 29 m, and 32 degrees 5 minutes Northern Declination. These two stars are about 25 degrees North of Procyon, the only first magnitude star in the constellation Canis Minor, the Little Dog. It is probable that Pollux will continue to gain in luminosity over Castor, for the spectroscope shows that Castor is going away from the solar system at nearly 5 miles per second, while Pollux is approaching at about 33 miles per second. Pollux is estimated to be at least 54 light years from the solar system, or more than 324 trillion miles. If the star continues to approach the earth at above rate, it will take more than 311,000 years to reach us.

Castor has been found to be a great binary system, and the two components can be easily separated by a small telescope. The two stars, Castor and his component, are revolving slowly around their common center of gravity, and while it has been about two centuries since they were found to be double,

they have really completed only about one-fifth of a revolution, the period being nearly 1000 years. The spectro-scope has revealed the fact that the fainter component is also a double star, one of them being opaque. It takes only about 3 days for these two to make a revolution. Thus Castor is known to be a system of 3 stars, though apparently only one.

There are many other wonderful lessons to learn about Gemini. If you examine with the unaided eye a small part of Gemini which contains Castor and Pollux, and then look through a six-inch reflector letting it cover the same space, you will be greatly surprised to find that while only 10 stars are visible to the naked eye more than 3200 can be seen distinctly through the telescope, some of them being stars of the 13th magnitude. If you should examine this same field looking through one of the most powerful telescopes of the present day, you would doubtless find many thousands more of stars, some of them being of the 14th, the 15th, the 16th and the 17th magnitudes.

CHAPTER TWENTY

PROCYON THE GREAT WHITE
STAR IN THE LITTLE DOG

This very beautiful white star is in Right Ascention 7 h 35 m, and 5 degrees and 27 minutes Northern Declination. It is the only bright star in the constellation Canis Minor, or the Lesser Dog. The light-giving power is fully 8 times as great as the sun, and its velocity at right angles to the line of sight is about 12 miles per second. Its spectrum is said to be intermediate between that of Sirius and the sun. This star is one of our near neighbors, but it is fully 10 light years away, or about 60,000,000,000,000 of miles. If a canon ball should be started there today, traveling at 20 miles per minute, or nearly 29,000 miles per day, it would require 5,707,000 years to span the distance.

Procyon is about 23 degrees almost exactly south of Pollux, and with Betelgeuse and Sirius it forms an equilateral triangle. It rises a few minutes earlier than Sirius. The spectroscope reveals the fact that this great star is approaching the sun at 6 miles per second, and if it continues to come towards us at this rate, it will take

more than 317,000 years to complete the journey.

Procyon is found to be a great binary system with a companion of the 13th magnitude, the distance between the two components being 5 seconds of a degree. While the companion star is faint, it is relatively very massive, and its presence first became known by the large irregularities which its attraction produces in the motion of the principal star Procyon. The great Lick telescope situated on Mount Hamilton, Calif., discovered the disturbing companion in 1895. The period of revolution of this great binary system about their common center of gravity is 40 years, in an orbit of about 1,800,000,000 miles. In other words, these two great suns are about as far from each other as Uranus is from the sun.

CHAPTER TWENTY-ONE

THE SEVEN GREAT SUNS OF THE BIG DIPPER

The beautiful and very conspicuous constellation *Ursa Major*, or the Great Bear, contains 133 stars that can be seen with the unaided eye. It is one of the great circum-polar constellations,

revolves around the North Pole of the heavens every twenty-four hours, and never goes below the horizon in the latitude of the United States. This constellation contains 7 stars, 6 of the second magnitude and 1 of the fourth magnitude, which form the Big Dipper, or Charles's Wain as it is called by English astronomers. The stars Alpha and Beta, or Dubhe and Merak, are called the *Pointers*, because a line drawn through these two stars and extended northward about 5 times the distance they are apart will terminate near Polaris, our present pole star. So after locating the Big Dipper it is an easy matter to find the pole star. The other five stars forming the dipper are, Phecda, Megrez, Alioth, Mizar and Benetnasch. Those astronomers who have given much attention to the study of the proper motion of stars have found that 5 stars of the dipper are traveling away from the sun at about 17 miles per second, while the other two are drifting in the opposite direction. From these circumstances it is evident that the dipper will not always hold its present form, but will in future ages be pulled apart.

Mizar at the bend of the handle is a very beautiful double star, requiring only a small telescope to get a good view of it. It was really the first double system to be discovered and was in the year 1650, only about 40 years after Galileo invented and used the first real telescope. These two great stars complete a revolution around their common center of gravity in about 20,000 years. The spectroscope reveals the fact that there is a third star revolving about *Mizar* in something like 104 days, this latter star being nearer *Mizar* than the other one. So when you look at *Mizar*, you really look at 3 great suns, though apparently only one. This great system is calculated to be fully 40 times as great in mass as our sun. A keen eye can see the faint star *Alcor* not far distant from *Mizar*.

By far the brightest of these great suns is *Alioth*, the star between the bend in the handle and the junction of the handle with the bowl of the dipper. It comes near being a first magnitude star in brightness. *Megrez* at the junction of the handle with the bowl is the faintest of the seven. *Benetnasch* at the end of the handle is next in brightness to *Megrez*. *Benetnasch* is a star of the Sirian type and

is so far away that its distance cannot be measured by the parallax method. By the revelation of the spectroscope it is found to be coming towards the solar system at the rate of 16 miles per second. This star is about 25 degrees from Dubhe, one of the pointers.

Dubhe the nearest pointer to the pole is a great spectroscopic binary, and is coming towards the earth at about 12 miles per second.

Merak the pointer farthest from the pole is a beautiful white star and is of the Sirian type. It is some 8 degrees from Phecda, the other star at the bottom of the bowl.

This very prominent and beautiful constellation Ursa Major, is also distinguished because of other noted objects now to be mentioned.

(1) *Groombridge 1830*, often called a "run-away" star, is traveling at a terrific speed, probably more than 200 miles per second. It is a sixth magnitude star, and therefore among the faintest to be seen with the naked eye. Yet it must be a very large sun, and at an enormous distance from us, for notwithstanding its great velocity it would take 100 years for it to pass

over a distance on the face of the sky equal to $\frac{1}{3}$ that of the diameter of the moon. It cannot be less than 200 trillions of miles, or 34 light years from the sun. Its rate of motion is so terrific, that while it could be turned into a new direction by a near approach to a great sun, yet it could not be stopped except by collision with a body of enormous size. Its proper motion is 7 seconds of a degree annually.

(2) *Planetary Nebula M. 97*. Speaking in general terms of Nebulae, they are faint looking objects appearing as specks of luminous clouds. Only two can be seen with the naked eye, but 10,000 of the irresolvable ones have been catalogued, and it has been estimated that there are at least 120,000 of them in reach of the great telescopes. Sir Wm. Herschel discovered a large number of them. The spectroscope shows that many of these luminous clouds are gaseous in character, and not made up of separate or individual suns. A large number of them lie relatively near the southern pole of the heavens. The Planetary Nebulae are nearly circular in form, and look much like the disks of the remoter planets of the solar system.

But back to the *Planetary Nebula M. 97 in Ursa Major*. It is located in Right Ascension 11 h 9 m, and 55 degrees 34 minutes Northern Declination. As viewed in a telescope of moderate size it has a faintly luminous disc near the size of Jupiter. But as viewed through more powerful glasses it appears to be more complicated in character. This great Nebula gives a spectrum of bright lines, which proves that it is gaseous. It has been calculated by astronomers that if this Nebula was located at a distance of 8 light years, or 48,000,000,000,000 miles from us, it would fill a space 7 times as great as the entire orbit of Neptune. But it is doubtless many times that distance, and cannot be seen without the aid of the telescope.

(3) *Xi Ursae Majoris*. This very beautiful 4th magnitude star is found in Right Ascension 11 h 13 m, and 32 degrees 6 minutes Northern Declination. It is a fine binary, but the components being only 2 seconds of a degree apart, they do not show up well in small telescopes. They revolve around their common center of gravity in about 61 years. The spectroscope shows that there is a third star in

this great system, so that while there appears to be only one star to the naked eye, there are really three in the system. This was one of the first great binary systems to be recognized, and it is notable because of the fact that it was really the first double system whose orbit was calculated on the principles of universal gravitation.

CHAPTER TWENTY-TWO CASSIOPEIA

This very beautiful constellation is exactly on the opposite side of Polaris from the Big Dipper, and is about 30 degrees from the pole. In all there are 67 stars visible to the unaided eye, but if a great telescope should be turned on this constellation there would appear hundreds of thousands of great suns. It can be easily traced out because of the peculiar shape of its most prominent stars. The 7 most conspicuous stars present the figure of a chair inverted, and according to the myth Cassiopeia is supposed to have occupied this chair as queen. *Kappa* on the front edge of the seat is only of the 4th magnitude and not so bright as the others. *Schedir* is the Alpha star of the constellation, and is a vari-

able with an irregular period. *Caph* the Beta star is white in color and of the second magnitude. It is situated on the equinoctial colure, and is on the same side of the pole as *Polaris*. *Gamma* the second star in the seat is at present considered the brightest in the constellation, although a few years ago *Alpha* was thought to be the brightest. *Delta* at the bend in the back of the chair is a second magnitude star, while *Epsilon* at the top of the back is of the third magnitude.

The other interesting objects in *Cassiopeia* are the following:

(1) The *Eta* star in *Cassiopeia* is one of the most interesting in the constellation. This star is located in Right Ascension 0h 43m, and 57 degrees 17 minutes Northern Declination. Look for it on some clear night. It will be found nearly between *Alpha* and *Gamma*, and about 2 degrees from the former. It is a great binary system of rapid motion and yields a large parallax. The components are yellow and purple in color, and are about 6 seconds of a degree apart. A 3-inch telescope will show the components in good shape. This great system is about 16 light years, or 96,000,000,000,000

miles from us. Suppose you try to count 96 trillions at the rate of one every second. In order to complete the task you would have to live 3,000,000 years. The components of this system revolve around their common center of gravity in about 206 years. It has been calculated that the light-giving power of this double system is about equal to that of our sun, and that the mean distance between them is 41 times that of the earth from the sun. In other words they are 1,000,000,000 miles further apart than the sun is from Neptune.

(2) *A Famous Temporary star* appeared in Cassiopeia in the year 1572, not far from Kappa. It has been called Tycho's star because it was carefully observed and described by Tycho Brahe. When at its best it was bright enough to be easily seen in the broad light of day. These phenomena come into view with amazing suddenness and as unexpectedly. As this star outshone the planet Jupiter it was much brighter than the first magnitude. There was no other star nearly so bright as this one when it burst forth on the evening of November 11, 1572. At first it increased in brightness till

it exceeded the planet Venus when shining at her best. But it finally began to lose its light, changing to redness as it did so, and in 16 months, or in March, 1574, it became invisible, and has not been seen since.

(3) *Iota in Cassiopeia*, located in Right Ascension 2 h 21 m, and 66 degrees 57 minutes Northern Declination is a great triple system. It is a 5th magnitude star and in the Milky Way.

Sigma in Cassiopeia, located in Right Ascension 23 h 54 m, and 55 degrees 12 minutes Northern Declination is a fine double star. It is of the 5th magnitude and situated a few degrees west of south from Beta.

A small telescope, or even an opera-glass, will bring to view many beautiful regions in Cassiopeia, which cannot be seen with the naked eye.

Near *Sigma* described above is a beautiful *cluster of small stars* discovered by Miss Caroline Herschel, sister of the great astronomer, Wm. Herschel. This leads to the remark that the great and fascinating field of astronomy is open as wide to women as it is to men, and there are a number of women who have become distinguished on account of their studies and researches in this noble science.

Something like a degree from *Delta* at the bend of the chair's back will be found another *fine field of stars*, if one will use a small glass. A person with a 3-inch telescope can spend a week or a month with great pleasure and profit in observing and studying the beautiful objects in and around Cassiopeia.

CHAPTER TWENTY-THREE

THE GREAT NEBULA IN ANDROMEDA

The constellation Andromeda is more than 30 degrees in length, and its main stars together with those of the Great Square of Pegasus suggest to some the outline of an immense dipper. While it is not at all comparable with the Big Dipper previously discussed, yet the enthusiastic and industrious searcher of the heavens will have no trouble in locating it. Find the Pleiades, look to the northwest about 35 degrees, and your eyes will be in the borders of Andromeda.

As we are now to consider briefly *Andromeda's Great Nebula*, it will be well at this time to locate it. You will find it in Right Ascension 0h

37 m, and 40 degrees 43 minutes Northern Declination. It is about 20 degrees almost due south from Cassiopeia's chair. As stated in Chapter Twenty-one, there are estimated to be at least 120,000 Nebulae in the entire heavens, but only two can be seen with the unaided eye. Andromeda's Nebula is one of the naked-eye objects.

In order to keep up with Andromeda and the Nebula, observe the following, remembering that this constellation is north of the celestial equator and also of the ecliptic. It therefore rises and sets north of the rising and setting sun.

About January 1, at 7 P. M., Andromeda lies just west of the meridian, February 1, at 7 P. M., it is 30 degrees further west; March 1, at 7 P. M., it is approaching the western horizon; April 1, at 7 P. M., it is just setting in the northwest; during May, June, and July, it is invisible in the evening sky, but August 1, at 9 P. M., it can be seen above the horizon in the northeast; September 1, at 8 P. M. it is advancing towards the meridian; October 1, at 7 P. M. it is nearly midway to the zenith; November 1, at 7 P. M., it is east of the meridian; December 1, at 7 P. M. it is almost on the meridian.

As to the *Great Nebula in Andromeda*, it is sometimes called "The Queen of the Nebulae." It is clearly seen on a moonless night, resembling a small cloud. In a 3-inch telescope it is large and round, but in larger glasses it appears elliptical. It is calculated to be $3\frac{1}{2}$ degrees in length, or fully 30,000 times the distance of the earth from the sun.

From the latest photographs of this Nebula, made with large telescopes, it appears to be spiral in form, and may in future ages develop into a great solar system.

The *Temporary star* of 1885 blazed out very suddenly near the center of the Nebula, continuing visible for about 6 months, and then faded out of sight till the most powerful telescopes were unable to reach it. It is fully believed that this star was actually in the Nebula, that is, that there was a real connection between the Nebula and the star.

Gamma in Andromeda, a third magnitude star about 16 degrees west of Algol, is one of the finest double stars to be found in the sky. The components are yellow and blue. The smaller one is itself a binary with a period of 55 years, and the eccentricity of its

orbit is very great. It is really a great system of three stars, though apparently only one.

CHAPTER TWENTY-FOUR

OTHER GREAT NEBULAS

Of the thousands of other Nebulous objects in the sky, we can consider only a few of the most prominent.

(1) *The Great Nebula in Orion.* This is one of the most noted of the large and irregular Nebulas, and is situated in Right Ascension 5 h 30 m, and 5 degrees 27 minutes Southern Declination. It is in one of the finest constellations in the entire heavens. In Chapter Sixteen we considered Rigel which is the great electric sun of this constellation. This Nebula surrounds the noted multiple star, Theta. It is strange that Galileo, who invented and used the first real telescope and gave much attention to the beautiful objects in Orion, overlooked this great Nebula. While this Nebula appears to the naked eye as one object, a 3-inch telescope shows that there are four stars, which are of the fifth, sixth, seventh and eighth magnitudes. They form what astronomers call the tra-

pezium of Orion. More powerful telescopes show two additional stars, making six in the trapezium. There are really many more smaller stars.

This Nebula is undoubtedly composed of luminous gas, and is not simply a cluster of small stars irresolvable in the great telescopes. Until some 60 years ago, astronomers supposed all the Nebulas of the sky to be irresolvable clusters of stars, but the wonderful spectroscope during the past half century has revealed the fact that a large number of these objects are composed of true gases. From later observations of this Nebula, it appears that the stars of the trapezium are not only optically connected with the Nebula, but are *physically* related to it, and are probably condensed from the gaseous matter of the Nebula. The light of this great Nebula comes from the luminous gas, hydrogen, and helium and the gas hitherto undetected upon earth which has been called Nebulum. We also learn from the spectroscope that this great Nebula is composed of the same elements as the stars of that constellation. It is without doubt as remote as are the stars about it, the distance being immeasurable, and it is getting further away from the solar

system at the rate of 10 miles per second, or 315,360,000 miles each year. Some believe that this great Nebula is at least 1000 light years from us, and if so, it will take 19,000 years for it to add another light year to its present distance.

(2) *Eta in the constellation Argo* is surrounded by a very magnificent Nebula. In appearance it is very much like the Great Nebula in Orion. It is in Right Ascension 10 h 41 m, and 59 degrees 10 minutes Southern Declination. It is a little less than 31 degrees from the south celestial pole, and therefore too far south to be observed in the United States. But the study of it is full of interest. It is situated in a very magnificent portion of the Milky Way. The most powerful telescopes are unable to resolve any part of it into stars, and it seems to be composed entirely of luminous gas. There are many stars scattered over it, and some of these may be physically connected with it. It is of vast extent, covering apparently a space about five times the area of the full moon, and therefore it must have vast dimensions.

The *Eta star* in Argo is one of the most remarkable stars in the sky, and appears near the middle of the Nebula

just described above. It is a variable star, and the history of its changes is full of interest. From the time of Halley's observations of it in 1677 to 1837 it was a naked-eye star ranging between the 2d and 4th magnitudes. But in 1837 it rapidly increased in brightness and became 1st magnitude, decreased somewhat in brightness again, and in the year 1843 it became almost as bright as Sirius. For several years following it gradually lost its brightness till it reached the 7th magnitude where it remains.

(3) *The Great Spiral Nebula in Canes Venatici.* This Nebula was observed and studied by Lord Rosse in his great telescope at Parsonstown, Ireland. It is the most noted of all the spiral Nebula, situated in Right Ascension 13 h 26 m, and 47 degrees 42 minutes Northern Declination, about 3 degrees southwest of Benetnasch, the star at the end of the Big Dipper's handle. This Nebula was discovered by Messier while he was engaged in hunting comets on October 13, 1773. The smaller telescopes show two Nebulas almost in contact, one smaller than the other, but in the more powerful glasses it appears as a wonderful spiral.

From the latest photographic work it has been shown that a considerable proportion of the Nebulas are spiral in form, and this form is now considered the rule, contrary to earlier opinions concerning Nebulas.

(4) *The Ring Nebula in Lyra.* This beautiful Nebula as it appears in the telescope is easy to find. It is in Right Ascension 18 h 50 m, and 32 degrees 54 minutes Northern Declination. It is near Beta in Lyra and about one-third the distance from Beta to Gamma, and about 10 degrees southeast from Vega. It can be seen in a low power telescope. The great Lick Observatory has given a very fine photograph of it. This is regarded as the most noted, and is thought to be possibly the nearest to us of the ring Nebulas. Only one bright line is shown in the spectrum. While Lord Rosse and other astronomers thought it could be resolved into stars, none are perceptible in the great telescopes of this country, and with the use of the spectroscope it is found by Huggins to be of a gaseous nature. Barnard found the central star in it to be inconspicuous and of the 15th magnitude. It is found to be about 81 seconds of an arc in length by 59 seconds of

arc in width, or double the apparent area of the disk of Jupiter. While little is known of its real size and distance, it seems evident that if the entire solar system should be placed in its center it would all occupy no more space than that covered by the central star. Enormous then must be its distance and vast the real size of this Nebula.

The great telescopes with the use of the photographic plates have brought to view 4,800 stars on and near the Nebula covering an area of 3 square degrees.

CHAPTER TWENTY-FIVE

SOME GREAT STAR CLUSTERS

In Chapter Nine we studied the Pleiades, or the Seven Stars. This as well as a few others can be seen with the naked eye. A number of others can be found with small telescopes.

(1) *The Great Globular Cluster in Hercules.* This cluster is found in Right Ascension 16 h 38 m, and 36 degrees 37 minutes Northern Declination. It is one of the most remarkable clusters in the heavens, and one of the finest for observation in the telescope. It is known as *Messier 13*

because it is No. 13 in Messier's catalogue. It is found on the star maps not far from the Apex of the sun's way, and between Zeta and Eta in Hercules. It is about 28 degrees nearly west of Vega. It appears as a hazy star of about the 6th magnitude in a good opera-glass. This beautiful and wonderful cluster was discovered by Halley in the year 1714, and when Messier observed it in a glass of low power, he thought it contained no stars. But when a great telescope is turned on the cluster it is found to contain a multitude of stars, which can be seen and counted. Observers through the Harvard telescope have counted 724 stars outside of the Nucleus. While the entire cluster contains at least 5,000 stars, Sir Wm. Herschel believed it contained as many as 14,000. Remember that a person with good strong eyes can see the cluster without the aid of a telescope. In a 3-inch telescope it is indeed a beautiful object, a number of its outlying stars being discerned. Some astronomers have estimated this great cluster to be 558 billions of miles in diameter, and the distance to be 65 light years from us, or 390 trillions of miles.

(2) *Cluster 92 Messier in Hercules.* This cluster is only a few degrees Northeast of the one just described above. It is between Eta and Iota, and about 50 degrees west of Deneb the great star in Cygnus which was discussed in Chapter Fifteen. It is located in Right Ascension 17 h 14 m, and 43 degrees 15 minutes Northern Declination. While the brighter stars of this cluster are easily reached by small telescopes, the cluster as a whole is not so bright nor so easily resolvable into stars as the cluster we have just been considering above. Wm. Herschel found it to be nearly 8 minutes of an arc in diameter, but its distance from the solar system is so vast that its real dimensions have never been estimated. Lord Rosse's great 6-ft. reflecting telescope was unable to resolve the central part into stars.

(3) *Globular Cluster Omega Centauri.* Sir John Herschel when studying this great cluster in a powerful telescope spoke of it as the richest and largest object of its kind in the heavens, and he declares the stars are literally innumerable and of the 13th and 15th magnitudes.

We now transfer from the Northern to the Southern Heavens. There are

some very fine globular clusters in the Southern Hemisphere, but probably none will exceed in magnificence the one now under consideration. It is located in Right Ascension 13 h 21 m, and 46 degrees 47 minutes Southern Declination. It is about 25 degrees southwest of Alpha Centauri previously studied, and about the same distance from Alpha Crucis. A few years ago this great cluster was photographed with a 13-inch telescope, and the individual stars can be distinctly seen and counted. While the telescope shows at least 6,500 stars in the cluster, it is believed that the real number is much greater. The dimensions of this cluster measure about 20 minutes of an arc, which is nearly $\frac{2}{3}$ the apparent diameter of the moon. To the unaided eye it has the appearance of a hazy comet, and is said to give as much light as a 4th magnitude star. This cluster has 125 variable stars, 98 of them having short periods of less than 24 hours.

CHAPTER TWENTY-SIX

THE STUPENDOUS VOYAGE OF
THE SOLAR SYSTEM

It will be well right here to turn back and read Chapter Eight. There it was found that the sun and his family are actually in motion, speeding through space at a rapid rate, covering about 350,000,000 miles annually, and that since the days of Adam the solar system has covered only 2,100,000,000,000 miles, or about one-twelfth the distance to the nearest star.

Since the invention of the telescope and the spectroscope, the direction in which the sun and his family are traveling has been found. The great astronomer, Wm. Herschel, was the first to make investigation on this very interesting and important question. It was in 1783, or 137 years ago that he began to study this subject. As a result of the study of the proper motion of stars as related to this theme, he arrived at the conclusion that the solar system is in rapid motion, traveling in the direction of the constellation Hercules, and the particular point toward which it is tending is located near the star Lambda in Hercules. This is near Right Ascension 17h 30m, and

36 degrees Northern Declination. This can be easily located on a good star map. It is something like 20 degrees southwest of the brilliant star Vega studied in Chapter Ten. This point towards which the sun is tending is called the Apex of the sun's way. The point opposite to this in the heavens, or that point from which the sun and his family are traveling is almost midway between the two great southern suns, Sirius and Canopus, discussed in Chapters Ten and Twelve. It is about 18 degrees nearly due south of Sirius. A little later, other astronomers as the result of their study of the subject, calculated that the point towards which the sun is traveling is about 10 degrees north of the point calculated by Herschel, or about 17 degrees a little south of west of Vega. A number of astronomers have since studied this question and while the results found by different ones vary to some extent, it is wonderful how nearly they all agree in locating the Apex of the sun's way. Newcomb is among the later ones who have given much study to this subject, and as a result of his studies the Apex of the sun's way, or the point toward which the solar system is traveling is placed near the

borders of Hercules and Lyra, not far from Right Ascension 18 h 30 m, and 35 degrees Northern Declination. This point is about 6 degrees southwest of Vega or something like 12 degrees northeast of the point fixed by Herschel.

The present trend, therefore, of the solar system is nearly towards Vega, and we learned in Chapter Ten that the relative rate of approach of the sun and Vega is about 11 miles per second and that at this rate it will take the sun 558,000 years to pass by Vega.

As the sun is traveling nearly towards Vega at the rate of 11 miles per second, or about 350,000,000 miles each year, it is evident that the stars in that quarter should open out from each other, and those in the opposite part of the heavens should close up behind, while those in the section of the heavens between should on the whole drift backwards, and this is exactly what is happening. We have many illustrations of this on the earth. For example, if we approach a grove of trees, they will seem to become larger and the spaces between them to open out, while those in the rear will seem to become smaller and to close up.

Sometimes it is asked, "How can the sun go forward carrying with him the 8 large planets, 600 asteroids, 25 moons, and a number of comets, and they all maintain their proper relations to him, seeing that the planets have their own motions around the sun, and the moons their motions around their respective planets"? Probably we can get some idea of this by using a familiar illustration. We are on a passenger train traveling forward at the rate of 50 miles an hour. While the car is in full speed a person walks from the rear to the front part of the car, and while doing so a fly fixes itself on his face. He brushes it off, and it flies around his head a number of times while he is walking through the car. The passengers who are seated have only one motion—that of the car. The person who walks through the car while it is in motion has two motions—that of the car and his own motion while he is walking. The fly has three motions—that of the car, that of the person who is walking through the car, and its own motion while flying. Notwithstanding all are on the same train, while the person walks forward he is traveling more rapidly than those who

remain seated, for he has the motion of the car, 50 miles per hour, plus his own motion while walking.

But it is believed that the solar system is moving in a curved path and not in a straight line, but so far as actual observations allow us to speak, we can only say that he has yet passed over a very small part of his mighty orbit. The sun will probably travel for hundreds or even thousands of years, before it will seem to deviate from a straight course. Whether it is traveling in a straight or curved path, it is certainly on a tremendous journey. If it is moving in a curved path, is this path an orbit, and will it therefore finally finish a revolution and in future ages come around to the position it now occupies in space? These are some questions not yet solved by astronomers.

The fascinating idea that somewhere in space there exists a great central star or sun, around which all the stars revolve, has had its advocates. It is a very beautiful theory, but few astronomers are inclined to put much confidence in it.

About 70 years ago, Maedler, a German astronomer, in one of his astronomical works took the position that

the entire stellar universe revolves around the center of gravity of the whole, and that Alcyone, the brightest star in the Pleiades, is the great central sun of the universe. Since then, others have advocated this theory, among them André in a published work on Stellar Astronomy. He argues the idea of a great central sun, contending that it agrees with many facts pertaining to the proper motion of stars. According to his published account of the matter, the solar system is distant from Alcyone about 4290 trillions of miles and will complete a revolution around that star in about 22,000,000 years.

CHAPTER TWENTY-SEVEN

THE PENETRATING POWER OF TELESCOPES

We are now entering another great subject, the telescope and its millions of lessons. I say *millions of lessons*, for that is true. Every star or sun, or other object in the heavens, invisible to the naked eye, but brought to view by means of the telescope, is really a new revelation, an added lesson to what we already know. The

human eye is a great scientific instrument, built by THE GREAT SCIENTIST, the Author of the Universe. It is wonderful how many things can be seen with the unaided eye. Reference is made to the human eye in the following passage of Scripture, (Gen. 15:5): "Look now towards heaven and tell the stars, if thou be able to number them, so shall thy seed be." Also the following: "Lift up your eyes on high, and behold who created these things, that brought out their host by number: He calleth them all by names by the greatness of His might, for that He is strong in power, not one faileth." (Isa. 40:26).

A very small per cent of the different objects that make up the universe can be seen with the naked eye. By far the larger number of objects composing the solar system must be seen, if seen at all, by means of the telescope. We can see the sun, Mercury, Venus, Mars, Jupiter, Saturn, our Moon, and under favorable conditions probably Uranus, with the naked eye. But Neptune, the 600 asteroids, Mars' two moons, Jupiter's eight, Saturn's ten, Uranus' four, and Neptune's one (making a total of 25 moons) are all invisible without telescopic aid. A

good strong eye can see distinctly upwards of 6000 stars in the entire heavens. This takes in all the stars down to and including the 6th magnitude. If one should look through a good opera-glass he would see stars of the 7th magnitude, and of these there are 13,000 in all. All the stars of the first seven magnitudes bring the number to about 20,000. A small astronomical objective glass, but a little more powerful than an opera-glass, penetrates to the 8th magnitude of stars, of which there are about 40,000. Now when we add together all the stars of the first 8 magnitudes we have 60,000 stars.

The light-gathering power of telescopes depends on the area of their object-glasses, and the amount of light collected is proportional to the square of the diameters of their object-glasses. The pupil of the human eye is about one-fifth of an inch in diameter. That being true, a 1-inch telescope will collect 25 times as much light from a star as the naked eye receives. It will therefore penetrate farther out into space and reach stars that cannot be reached by the unaided eye.

If you look through a 1--inch telescope, you will see stars of the 9th magnitude, and there are 120,000 of

these. Putting together all the stars of the first 9 magnitudes, we have about 180,000.

Next suppose you study the heavens through a telescope with an object-glass of 2 inches in diameter. On the principle stated above, the 2-inch glass receives 100 times as much light as the naked eye, and brings to view 10th magnitude stars, of which there are 380,000. Adding these to the total above mentioned we have 560,000 stars of the first 10 magnitudes.

Try next a telescope with a 3-inch object-glass. This telescope receives 225 times as much light as the naked eye, and penetrates farther out into space bringing to view stars of the 11th magnitude. Of the 11th magnitude stars there are 1,000,000, making a total of 1,560,000 stars of the first 11 magnitudes. A 4-inch telescope will enable one to look at stars of the 12th magnitude of which there are 3,000,000. This makes 4,560,000 stars of the first 12 magnitudes, and the 4-inch glass receives 400 times as much light as the naked eye.

That part of the universe thus far found has begun to take on some dimensions. We now wish to introduce the 7-inch telescope, which is capable of

receiving 1225 times as much light as the unaided eye, and by its penetrating power it reaches stars of the 13th magnitude, of which there are 9,000,000. This makes a grand total of 13,560,000 stars of the first 13 magnitudes. If one should undertake to count all these stars it would require more than 5 months, counting one star every second, night and day.

To those who may have a curiosity to look through the largest telescopes, we would like to say that they will find the moderate glasses more satisfactory. And they should also remember that a large proportion of the astronomical discoveries have been made with relatively small glasses, and very much of the solid astronomical work of the present time is carried on with meridian circles which have glasses ranging from 4 to 8 inches in diameter.

Sir Wm. Herschel discovered the planet Uranus and many hundreds of beautiful Nebulas with a small glass. The 4 larger moons of Jupiter, the rings of Saturn and the mountains and craters of the moon were discovered with a small glass. W. S. Burnham, an enthusiastic and industrious astronomer of Chicago made himself famous

by the use of a 6-inch telescope. He purchased his instrument from Clark and Son of Cambridge, Mass., and discovered many hundreds of double stars so difficult that they had escaped the attention of those using larger glasses. On Mount Hamilton, California, afterwards the site of the great Lick telescope, he discovered nearly 50 new double stars, all of which were unknown to previous observers, using his 6-inch telescope.

Let us next introduce the 10-inch telescope. This instrument receives 2500 times as much light as the naked eye, and its penetrating power is so vast that it reaches stars of the 14th magnitude, of which there are 27,000,000. These with the former total bring the number of stars of the first 14 magnitudes to upwards of 40,000,000. It would require one year and three months to count these, counting one every second night and day.

In order to reach stars of the 15th, 16th and 17th magnitudes, it requires the largest telescopes. The great Yerkes glass with 40 inches aperture barely brings to view stars of the 17th magnitude. The penetrating power of this glass is enormous. It receives 40,000

times as much light as the naked eye, and reenforced by celestial photography, it brings to view not less than 100,000,000 shining suns. In order to count them one must spend 3 years and 2 months, counting night and day, one every second.

ERRATA

On page 25, third line from the top, read part for par.

On page 29, sixteenth line from top, read Southern instead of southern.

Doubtless a few other typographical errors will be found.

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